Scope of sustainability – Do castor beans and the biodiesel industry offer family farmers a sustainable development opportunity in Brazil?

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Keywords: family farming, biofuels, sustainability assessment, sustainability indicators

Introduction

Sustainable bio-energy is interwoven with sustainable rural development for family farmers. In this context, the Brazilian government is pursuing a "social inclusion" goal by means of family farmers providing a fraction of biodiesel feedstock. In 2009, the state-run petroleum company established a biodiesel plant in the north of Minas Gerais State. Family farmers in this region are faced with the prospect of entering agreements with the industry to provide castor beans (castor). Fewer family farmers than anticipated are engaging and this raises doubts regarding the sustainability of this option for family farmers (da Silva César and Batalha 2010). Exploration into the sustainability of such farmer-industry agreements from the farm-level perspective is timely. We conduct an exploratory assessment using sustainability indicators. We aim to: (i) capture and explore the scope of sustainability if family farmers choose to cultivate castor and (ii) explain sustainability as a function of current yield levels, alternative yield levels and alternative management decisions at the farm level.

Material and Methods

Case study area and farming system

Montes Claros is a municipality in the north of Minas Gerais. The mean annual rainfall is 1035 mm with 940 mm falling during the distinct wet season. We focus on the most numerous family farm type within Montes Claros identified and described using a similar farm typology as Tittonell et al. (2005). This is an extensive cattle system where the main plant production activities are Brachiaria pasture (30 ha), maize grain for cattle intercropped with beans in the same rows for the household (1-2 ha) and sugarcane for cattle (1 ha). The average herd size is 25 heads and cheese is the most common income-generating product. Labour is sourced from the household and supplementary animal feed during the dry season accounts for most of the purchased inputs annually.

Sustainability assessment

We selected four farms from a household survey to represent the range in combinations of current maize and milk productivity. 'Farm 1' represents low maize and milk yields (340 kg ha^{-1} and 436 l cow^{-1} $year^{-1}$), 'Farm 2' represents moderate maize and high milk yields (1148 kg ha^{-1} and 2555 l cow^{-1} $year^{-1}$), 'Farm 3' represents moderate maize and high milk yields (2550 kg ha^{-1} and 2268 l cow^{-1} $year^{-1}$) and 'Farm 4' represents high maize and moderate milk yields (4080 kg ha^{-1} and 1200 l cow^{-1} $year^{-1}$). Sixteen alternative scenarios were designed to capture different combinations of castor yield levels with different farm-level management decisions relating to cropping area and animal feeding. Four levels of achievable castor yields were included (289, 560, 642, 1139 kg ha^{-1}). These were sampled from a literature review of relevant castor trials conducted in Brazil. Two land use decisions of contrasting castor areas were included (*Castor area 1*: to replace 1 ha of area currently cropped with maize and beans with castor and beans; *Castor area 2*: to replace the total area currently cropped with maize and beans plus 1 hectare under pasture with castor and beans). Two different animal feeding strategies in the light of sacrificing on-farm fodder production were included (*Feeding strategy 1*: to replace all sacrificed maize and pasture production by purchasing supplementary maize and renting additional pasture; *Feeding strategy 2*: to sacrifice milk yields due to losses in fodder production).

Three sustainability criteria relevant to family farmers in Montes Claros while also consistent with broader debates about sustainable bioenergy were selected. These are that biofuel production should: contribute to economic development of family farmers; increase the stability of family farmer livelihoods and; retain or improve the soil and soil fertility. Justifications for these criteria are that in Montes Claros household income is currently subsidized by the government and we observed economic motivations driving a trend away from family farming. Further, households experience high levels of climate driven risk leading to unstable incomes between dry and wet seasons as well as between dry and wet years. Finally, soil fertility decline is evident in Montes Claros. We observed bare soil, soil erosion and farmers have reported pasture productivity decline. Indicators of performance against these criteria were selected and calculated according to the methods in Table 1 for 68 farms (4 current + 4 *X* 16 alternatives). Indicator values and values relative to the respective current farms were compared between farms, castor yield levels, castor areas and feeding strategies.

Results and discussion

Table 2 shows that against the indicators in this study, on average, castor does not improve the performance of this farming system. However, the N-balance is an exception where on average more nitrogen is retained in the system due to the castor activity. Large ranges in all the indicator changes in this table demonstrate the impact of current productivity and the alternative scenarios on indicator scores. Current productivity proves to be an important determinant. E.g. Figure 1a shows that household income consistently increases due to castor for 'Farm 1' while income is reduced for the other 3 farms. For the latter 3 farms we see the importance of maize to support animal production such that the introduction of castor at the expense of current crop production proves less favourable. It is also shown that the highest yielding castor activity (open circles in Figure 1a) results in an increase in household income while the other yield levels decrease household income. As well, the high yielding activity is the only example with an average improvement in labour use efficiency (reduction of 0.1 days 100R$$^{-1}$ versus an average increase of 0.2 days 100R$$^{-1}$ for the other three yield levels). The spatial extent of castor cultivation significantly impacts labour and purchased inputs where the larger area under castor demands significantly more cash and labour. Figure 1b shows the results for purchased inputs. This figure also shows that this indicator is impacted by different feeding strategies. Supplementing all maize replaced by castor with the equivalent in purchased feed (feeding strategy 1) is less favourable in terms inputs compared with feeding strategy 2 (open circles in Figure 1b).

In terms of the economic development, stability of livelihood and soil fertility criteria studied here there are opportunities for policy makers and farmers to enhance the sustainable development afforded to farmers through cultivation of castor. Against the economic development indicator, current 'low-productivity' farms such as 'Farm 1' have greater scope for improving performance with castor. The sustainability scope for currently 'high-productivity' farms is restricted to scenarios with high yielding castor. There is a need to tread carefully when impacting current animal production as we show that increasing the area of castor beyond the currently cropped area is not desirable due to the greater demand on purchased and labour inputs.

References

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Figures and Tables

Table 1. Sustainability criteria and indicators for a farm-level sustainability assessment of castor entering the family farming system in Montes Claros

Selected sustainability criteria	Selected indicators *(calculation method for a single year)*
Biofuel production should contribute to economic development of family farmers	Income (R$ household^{-1}) *(on-farm revenues minus on farm expenses)*
Biofuel production should increase the stability of family farmer livelihood	Labour inputs and labour use efficiency (days year^{-1}; days 100R^{-1}) *(sum of labour hours for each activity performed on-farm; labour inputs divided by income)*
	Purchased inputs and purchased inputs use efficiency (R$ year^{-1}; R$ R$$^{-1}$) *(sum of purchased inputs such as fertilizers and animal feeds for each on-farm activity; purchased inputs divided by income)*
Biofuel production should retain or improve the soil and soil fertility	Nitrogen balance (kg ha^{-1}) *(change in soil nitrogen stock within one year; the sum of nitrogen inputs minus the sum of nitrogen outputs)*

Table 2. Mean (and range) of changes in indicator values relative to the current farming systems

Indicator	Mean (range)
Income (R$ household^{-1})	-335 (-2878 to +2125)
Labour use efficiency (days100 R$$^{-1}$)	+0.1* (-1.9 to +0.9)
Labour inputs (days)	+16.3 (-2.0 to +41.6)
Purchased inputs use efficiency (R$ R$$^{-1}$)	+0.05* (+0.02 to +0.18)
Purchased inputs (R$)	+838 (0 to +3634)
Farm gate N-balance (kg ha^{-1})	+3 (-8 to +24)

* Positive change indicates a reduction in efficiency

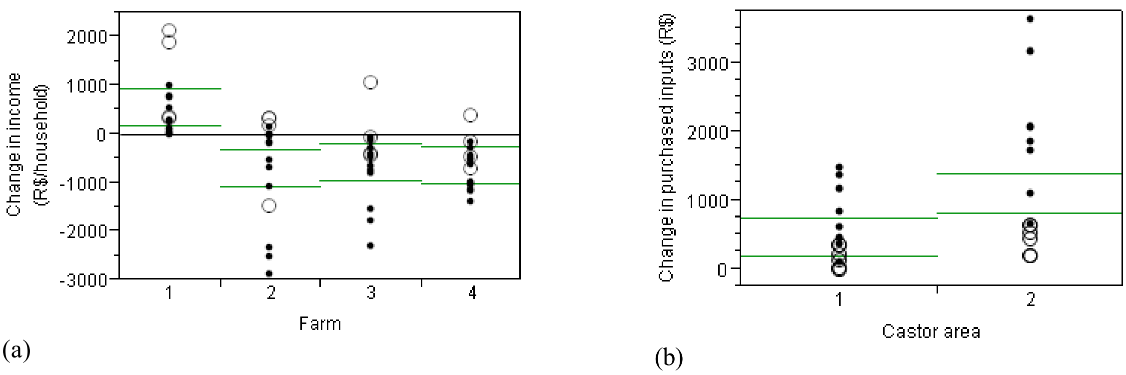

Figure 1. Change in indicators due to castor area scenarios grouped by productivity and decision variables with lines indicating 95% confidence intervals about the group means (a) Income indicator by current farms, open circles show the high yielding (1139 kg ha^{-1}) castor activity (b) Purchased inputs indicator by alternative extent scenario, open circles show the feeding strategy 2.